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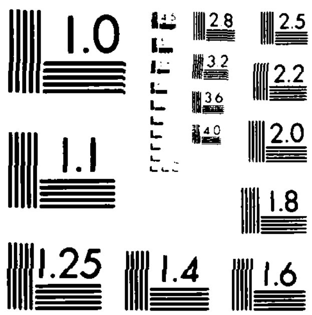

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THE USE OF SCREENING IN POLICY ANALYSIS

Warren E. Walker

January 1984

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ABSTRACT

In most policy analysis studies there are a large number of alternative policies and a large number of impacts to be considered. Time and budget constraints make it impossible to calculate all the impacts for all of the alternatives. As a result, such studies include some process for reducing the number of alternatives to be examined in detail. The process is often implicit and non-scientific (e.g., only the decisionmaker's three favorite alternatives are considered).

This paper suggests that policy analysis studies explicitly include a screening step, in which the alternatives to be examined in detail and those to be excluded from further consideration are chosen in a scientific and systematic manner. The output from this step is a relatively small set of policy alternatives that are sufficiently attractive that they deserve a more thorough evaluation. Two general screening strategies are described. They are illustrated by describing the screening step in a study to help determine an overall water management policy for the Netherlands.

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I. INTRODUCTION

Policy analysis is an organized, systematic approach to problem solving. It can be used to study the problems of almost any system: health systems, political systems, industrial systems, urban service systems, etc. Although the analyses of different problems often show little resemblance, they almost always involve performing the same set of logical steps. By now these steps are so well known and so well documented in the literature that they are referred to as "the classic steps of systems analysis" (see, for example, [12, p. 70] and [6, p. 10].) The steps are summarized in Fig. 1.

In any large policy study there are likely to be numerous measures of performance to be considered. As a result, the enumeration and evaluation of all of the alternatives as called for in Steps 4 and 5 of Fig. 1 will be impossible to carry out within reasonable time and budget constraints. In addition, as pointed out by de Neufville and Stafford [1, p. 9]: "Even if it were feasible to think of all variations, common sense suggests that the investigation of all alternatives is not worthwhile: some are not sufficiently different to warrant separate treatment for each and some are clearly dominated by others."

The situation poses a problem for policy analysts. How can they carry out a study that considers the full range of alternatives within their time and budget constraints? In most cases, they solve this problem by performing an incomplete analysis. They ignore some impacts, examine a small subset of the alternatives, or both. In a public policy study, many if not most of the impacts of a policy will be hard to quantify (e.g., changes in the quality of life) or hard to represent in common units such as dollars (e.g., the loss of a game preserve or an increase in noise pollution). The usual response to this is to ignore all but a few of the impacts in performing the analysis. This is the approach generally taken when cost/benefit analysis or optimization models are used to find the "best" policy.

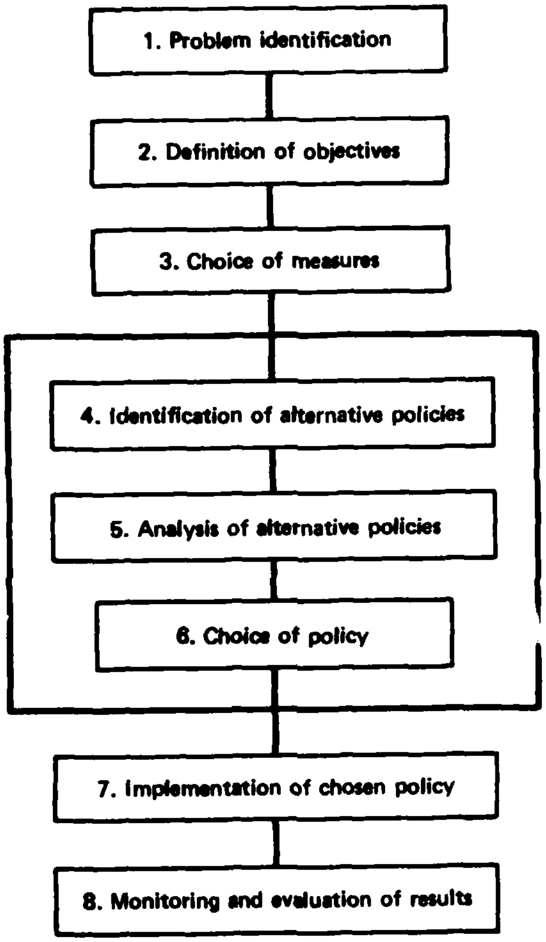

Fig. 1 — Steps in a policy analysis study

A second solution to the problem that makes it feasible to consider the full range of impacts and alternatives is to split Step 5 in Fig. 1 into two steps, as shown in Fig. 2. In Step 5a, screening models would be used to eliminate the least promising (or to select the most promising) alternatives. The output from this step is a restriction of the set of alternatives to a small set that appear to be promising--i.e., are sufficiently sensible and beneficial that they merit a more thorough evaluation. A detailed examination of the remaining alternatives (which we will call "impact assessment") would then be carried out in Step 5b.

Although screening is implicitly carried out in most large policy analysis studies, it is usually not performed in a rigorous or systematic way. The purpose of this paper is to point out that, although a policy study should not be designed to find the "optimum" policy, it should use as rational a process as possible to identify good policies. As Manheim [8, p. 182] expressed it:

> "In such a process, we try to find as good a solution as possible, balancing the prospects of improving the solution against the expenditures of...resources required to do so."

The literature on screening is extremely sparse. Mood [11, p. 33] and the *Handbook of Systems Analysis* [10] make passing reference to the concept. Examples of the use of screening in public policy studies are contained in [2], [3], [4], [5], [7], [9], and [13]. Although the specifics of the screening will depend on the system and policy problem being analyzed, there are two basic screening strategies. These are described in Section II. In Section III we use one of the aforementioned studies to illustrate the two strategies.

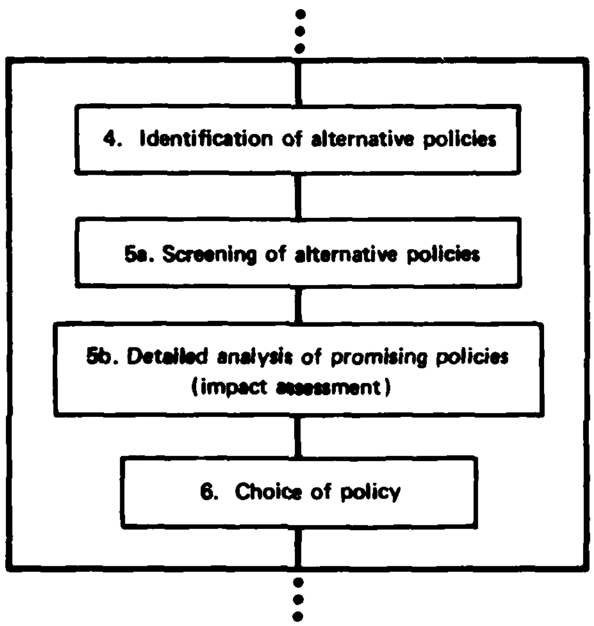

Fig. 2 — Addition of a screening step

II. SCREENING STRATEGIES

Since the purpose of screening is to narrow the range of alternatives needed to be examined in detail, its value increases as it becomes easier, cheaper, or faster to eliminate alternatives. Its value decreases as it becomes less discriminating, less reliable, or more costly. There are certain features that any worthwhile screening procedure should possess, and certain universal screening rules that apply to practically every situation. Two properties of good screening prodedures are: (1) no very good alternative will be missed, and (2) the number of alternatives to be evaluated in impact assessment will be relatively small. Mood [11, p. 33] and Goeller et al. [5, p. 240] mention several general screening principles, including:

- *Infeasibility.* If some technical, economic, or administrative difficulty or some organizational constraint will prevent implementation of an alternative, it is probably not worthwhile to pursue it.
- *Political unacceptability.* If an alternative appears to be unacceptable to large segments of the public or to the decisionmakers who must ultimately decide on its adoption, then it might as well be left out of consideration. (In some cases, the potential benefits from the alternative might be so large that the opposition would dissipate when the analytical results were presented. However, this is a rare event.)
- *Dominance.* If two alternatives have the same purpose and the benefits from one are at least as good as the benefits from the other for all important measures of performance, then the latter can be dropped from further consideration. (Dominance is usually not easy to find or to show.)

Practically all structured screening procedures employ one or both of the following "pure" strategies:

(1) *Use Limited Number of Impact Measures.* This strategy starts with a large number of well-defined alternatives and eliminates unpromising ones (usually one at a time) by evaluating their performance on a few key measures. Its major benefit is to speed up the evaluation of well-defined alternatives.

(2) *Bound Space of Promising Alternatives.* This strategy eliminates sets of potential alternatives before evaluating any specific ones by placing constraints on the characteristics of promising alternatives. Its major benefit is to focus the search for the well-defined alternatives to be evaluated.

In most actual studies some mixed strategy is used. The relationship between the two pure strategies is similar to the relationship between primal and dual linear programs. In the primal, a sequence of feasible solutions is evaluated. The dual is a drive through non-feasible solutions toward the feasible space. In Strategy 1, a set of well-defined alternatives is evaluated. Strategy 2 constrains the space in which "good" alternatives are to be found.

STRATEGY 1: USE A LIMITED NUMBER OF IMPACT MEASURES

The essence of this approach to screening is (1) to construct an extensive and diverse list of alternatives that may or may not turn out to be promising, and (2) to produce a short list of promising tactics by means of limited, broad-brush assessments based on a small number of impact measures. Manheim refers to this as "sketch planning" [7, p. 585].

As an illustration, the entire process can be compared to the steps most people follow in buying a new house. A broker generally has too many houses listed to enable a potential buyer to visit each individually. However, a few basic criteria such as neighborhood, purchase price, and number of rooms will normally reduce the number of alternatives significantly. Then more detailed criteria, such as the layout of rooms, condition of plumbing, etc., can be considered for the remaining houses. If this strategy is followed, it is possible that one's "dream house" will be screened out in the first stage (e.g., because the price is slightly too high); but the result is usually quite satisfactory. Figure 3 is a schematic depiction of this approach.

Walker and Veen [14] applied this strategy to the screening of policy options (which they called "technical and managerial tactics") that would change the movement and storage of water in the rivers, canals, and lakes of the Netherlands. The tactics were designed to alleviate problems caused by shortages of surface water and/or by the salinity of the water. Most of the screening was performed using two measures: the tactic's construction cost and the resulting reduction in the country's agricultural losses. A more complete description of this screening analysis is presented in Section III.

Similar approaches were used in three other Rand Corporation studies. Two of them ([2] and [3]) were concerned with ways to reduce air pollution. The studies were interested in analyzing air pollution control alternatives in terms of a wide variety of environmental, transportational, economic, and distributional impacts. However, in each study the number of feasible alternatives was so vast that it was impractical to evaluate all of them in terms of detailed impacts. Alternatives were screened after calculating only their costs and effectiveness in reducing emissions.

The third Rand Study [4] examined the possible consequences of alternative ways of protecting the Oosterschelde, an estuary in the southwestern Netherlands, against North Sea flooding. The impacts considered in the analysis included the security of people and property from flooding; the financial costs of constructing and operating protective facilities; the changes in the ecology of the region, the economic effects; the water management impacts; and the various social effects, including the displacement of households. The screening analysis concentrated on a few impacts related to security, ecology, and construction costs. For example, any alternative that would provide the desired level of security with a higher cost and a less desirable ecology than some other alternative was ruled out.

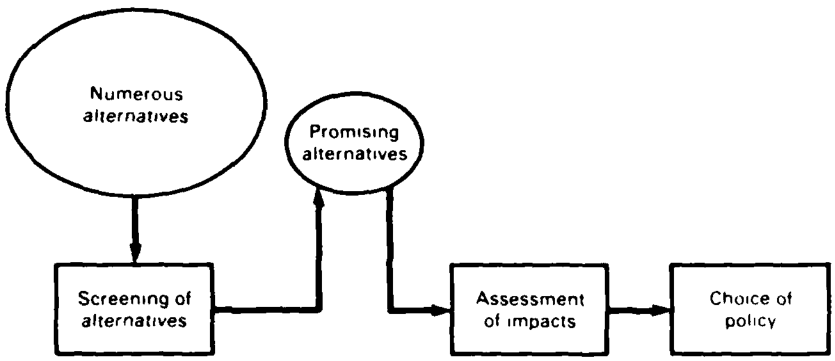

Fig. 3 — A screening strategy that eliminates unpromising alternatives

STRATEGY 2: BOUND THE SPACE OF PROMISING ALTERNATIVES

The essence of this strategy is to place constraints on the characteristics that promising alternatives must possess. After screening, there would be very few alternatives left to evaluate because very few could be defined that would possess these characteristics. The screening process itself may end in the identification of a single promising alternative, or the step after screening might be to identify the feasible alternatives (if any) within the restricted decision space (see Fig. 4).

The art in this strategy lies in specifying the constraints on the alternatives. Many of the constraints are likely to be quite arbitrary. However, if the constraints are specified well, the strategy can be very efficient. Each constraint can eliminate entire sets of alternatives. For example, if all promising alternative highway routes between City A and City B had to pass through City C, large numbers of possible routes could be eliminated immediately.

Manheim [8] provides a highly structured example of the use of this strategy. He presents an optimal search branch-and-bound algorithm that concludes with a restricted decision space containing a single alternative. The specific application is highway route location. Full specification of a single alternative may require assigning values to over 30,000 variables. However, in his approach, the location process passes through several stages. In each successive stage, the degree of detail with which the alternatives are specified is increased, so that, only in the final phase (called "final design") are the specific values of all the variables assigned.

This strategy for screening can be compared to the approach commonly used in designing a building. The process starts with an evaluation of alternative functional requirements for the building. There may be many possibilities. In this step all but a few are ruled out. This is then followed in sequence by the specification of building requirements, the drawing up of general plans for the building, and the drawing up of detailed blueprints. At each step, large numbers of possible blueprints are being eliminated without their having to be drawn.

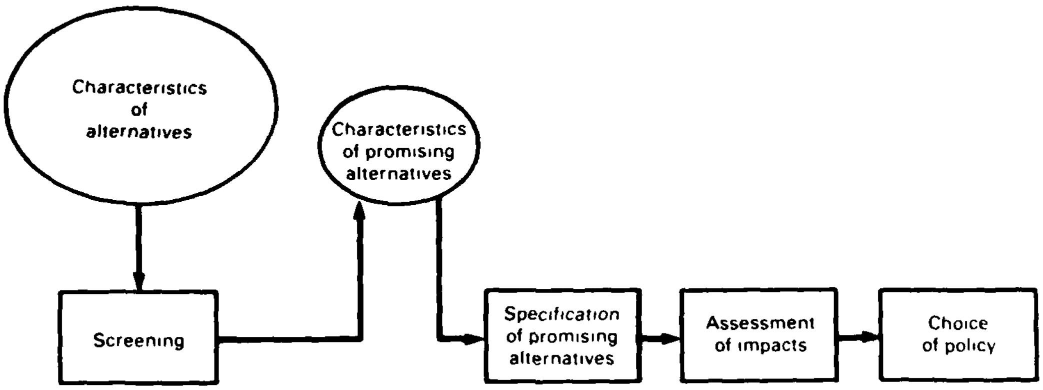

Fig. 4 — A screening strategy that bounds
the space of promising alternatives

Variations on this strategy have been used in several policy studies besides Manheim's. Walker and Veen [14] applied it as a first step in their screening of technical and managerial tactics for water management in the Netherlands. They calculated an upper bound on the expected reduction in agricultural losses that tactics could produce in each of the eight regions of the country. The upper bound was so small in two of the regions that no tactics pertaining to these regions were evaluated. (See Section III.)

Martland et al. [9, p. 14] report that the U.S. Department of Transportation (DOT) used this strategy to determine which parts of the railroad system in the Midwest and Northeast Region should be subjected to detailed scrutiny to see if there was excess capacity. Using a statistical study of branch line operations, DOT was able to determine the relationship between a branch's profitability and the independent variables line length and traffic volume. As a result, it could identify, for branch lines of any length, the range of traffic volumes that would be potentially unprofitable. After analyzing every branch line in the region using this criterion, DOT found that 25 percent of the mileage was "potentially excess." It then concluded: "These are the lines which should receive the closest analysis in the process of restructuring the local rail service network."

Rogers and Berry [13] used a similar idea to find urban telephone feeder routes whose length and population distribution make a pair gain system (PGS) installation economically feasible.[1] For a route of given length and population distribution, their screening model defines the set of locations at which a PGS installation is cheaper than using only additional copper wire pairs to meet subscriber growth.

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[1] In a PGS installation, the signals from many copper wire pairs (individual subscribers' lines) are concentrated and multiplexed onto many fewer pairs.

III. SCREENING IN PAWN

OVERVIEW

In 1976 a severe drought cost the Netherlands more than $2 billion in agricultural losses. In addition, low river levels caused serious shipping delays and substantial economic losses because ships could not navigate the waterways with full loads, and the water shortage worsened water quality problems. In 1977, the Dutch government commissioned a broad study of the country's water management system. The resulting project, called Policy Analysis of Water Management for the Netherlands (PAWN), was a 3-year, 125 man-year effort conducted jointly by the Rand Corporation, the Rijkswaterstaat (the government agency responsible for water control and public works), and the Delft Hydraulics Laboratory (a Dutch research organization.)[1] The objectives of PAWN were twofold:

(1) to develop a methodology for assessing the multiple consequences of water management policies, and
(2) to apply this methodology to evaluate a number of alternative water management policies.

The study considered a wide range of consequences of the water management policies (the consequences were called "impacts"). Impact measures were defined to cover the objectives of all affected groups (e.g., farmers, shippers, industrial firms, the country's ecology, public health, etc.), and to reflect both equity and efficiency considerations. Table 1 lists a subset of the measures used by PAWN in assessing the impacts of alternative water management policies.

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[1] Results of the study have been documented in a series of 21 publications. Goeller et al. [5] provide an overview of the methodology and a summary of the results. Walker and Veen [14] provide details of the screening analysis.

Table 1

PAWN'S IMPACT ASSESSMENT MEASURES

Impacts on Water Management System

Costs of tactic
Risk of flooding

Direct Impacts on Users

1. Agriculture
   Gross benefits
     By crop (13 crops)
     By region (8 regions)
   Sprinkler costs (fixed and variable)
   Net benefits (by who receives benefits)
     Dutch (producers, consumers, government)
     Foreign (producers, consumers, government)
2. Shipping
   Low water losses (Dutch and foreign)
   Lock delay losses (Dutch and foreign)
   Annualized cost of changing fleet (Dutch and foreign)

3. Power Plants

4. Industrial Firms and Drinking Water Companies
   Revenues of drinking water companies
     From commercial firms
     From industrial firms
     From households
   Cost of supplying drinking water
   The percentage of groundwater in drinking water
   Total industrial water consumption (by source)
   Industrial cost increases (taxes, drinking water costs, etc.)

5. Other users
   Lock delays for recreational boats
   Miles of fresh water beaches

Impacts on the Environment

Violations of water quality standards (salinity, chromium, BOD, phosphates, heat)
Changes in groundwater levels
Algae growth
Damage to nature from constructing facilities

Impacts on Entire Nation

Jobs
Sales
Trade
Public health
Government revenues

A water management *policy* involves a mix of *tactics*, each a single action to affect water management, such as building a particular canal or taxing a particular use. Four kinds of tactics were distinguished in PAWN:

(1) *Technical tactics*, which add to or modify the current water management infrastructure (e.g., dig a new canal, enlarge a pumping station, or build a dike)
(2) *Managerial tactics*, which change the rules by which a particular infrastructure is operated (e.g., change the operation of weirs, pumps, and sluices so as to affect the water level in lakes or the flow in rivers and canals)
(3) *Pricing tactics*, which impose a charge on water use or discharge.
(4) *Regulation tactics*, which control water use or discharge with legal and administrative measures.

The first two kinds of tactics directly affect the supply of water to particular users; the last two directly affect users' demand for water. Different screening approaches were used for the first two and last two kinds of tactics. In the remainder of the paper we describe the screening of technical and managerial tactics.

ESTIMATION OF COSTS AND BENEFITS

Tactics were determined to be promising or unpromising based on a comparison of their costs and benefits. The cost assigned to a tactic was its annualized fixed cost (AFC).[2] Operating costs (which were mainly the cost of electricity to run pumps) were ignored because they were very small relative to the fixed costs.

The benefits and disbenefits from alternative water management policies accrue primarily to the direct users of water: farmers, shippers, industries, and drinking water companies. The policies also

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[2] A tactic's AFC was obtained by applying a capital recovery factor of 0.10 to the investment cost and adding the fixed annual operating cost. A capital recovery factor of 0.10 reflects a useful life of approximately 50 years and a discount rate of 10 percent.

have more global impacts, such as on consumers, the environment, and other countries. In screening, attention was focused on agriculture, since it is the largest consumer of water, and it suffers most from water shortages and salinity. The use of water by agriculture is about 9 times that of the drinking water companies and 50 times that of industries. In 1976 it is estimated that agriculture suffered losses of over 6 billion guilders due to water shortages and about 500 million guilders due to the salinity of the water used to irrigate crops.[3] The impacts of the tactics on shipping (which is affected by low water levels on the nation's waterways) were also considered.

The benefits from a tactic are defined as the difference between the losses to agriculture and shipping if the tactic is implemented and the losses to those user categories without the tactic. The major categories of losses that were considered in the screening analysis are:

- *Agriculture shortage losses.* If a tactic increases the supply of water to an area, then, in years with low rainfall, a small proportion of the crops will die due to an insufficient amount of water. The benefits from increased supply are therefore measured in terms of reduced agriculture shortage losses.
- *Agriculture salinity losses.* If a tactic is able to reduce the salinity of water supplied to agriculture, then a smaller proportion of the crops will be damaged by salt. The benefits from reduced salinity are therefore measured in terms of reduced crop losses due to salinity damage.
- *Low water shipping losses.* If the depths of the country's waterways are not sufficient, ships cannot carry their maximum loads, but must travel with less cargo to reduce their drafts. This means more trips and higher operating costs for transporting a given amount of goods. Tactics that change flows and water levels on certain waterways will affect shipping depths. The benefits from these tactics are measured in terms of a reduction in shipping losses.

[3] A guilder is worth approximately $0.33.

The benefits from a tactic vary from year to year depending on the rainfall and river flows. For example, tactics designed to reduce shortage losses will produce higher benefits in dry years than in wet years. Thus, since river flows and rainfall vary from year to year, the benefits of a tactic for any year are unpredictable. To compare a tactic's benefits to its cost, an estimate of its *expected* benefits (the average over many years) was needed. The approach used, which is described below, produces upper and lower bounds on the expected annual benefits by taking weighted averages of the benefits in four years that had very different rainfall and river flow patterns (1943, 1959, 1967, and 1976).

Based on the losses to agriculture for the years 1933 through 1976, it was estimated that both the shortage and salinity losses associated with 1976 would be exceeded only one year in 44, or in approximately 2 percent of all years. The exceedence probabilities for the other three years were also calculated. The results for the four "external supply scenario" years are given in Table 2.

To obtain the upper bound for expected annual benefits, it was assumed that the benefits in 1976 would be obtained in all years drier than 1959; the benefits in 1959 would be obtained in all years between 1959 and 1943 in dryness; etc.[4] For the lower bound it was assumed that

Table 2

PROBABILITIES OF ANNUAL LOSSES EXCEEDING
THOSE OF FOUR SCENARIO YEARS

	1976	1959	1943	1967
Shortage losses	.02	.07	.21	.63
Salinity	.02	.09	.13	.57

[4] Treating a tactic as promising if its annualized fixed cost is less than the upper bound on its expected annual benefits is therefore very conservative. A year as bad as 1976 is treated as if it is expected to occur once every 11 or 14 years instead of once every 50 years. So only very poor tactics will be screened out.

the 1976 benefits would be obtained in all years drier than 1976; 1959 benefits would be obtained in a year between 1976 and 1959 in dryness, etc.; it was also assumed that there would be no benefits from the tactics in any year wetter than 1967.

Letting B(y) be the benefits obtained in year y from implementing a tactic, the formulas for upper and lower bounds on the expected annual benefits (EAB) are:

For shortage losses:

$$.02B(1976) + .05B(1959) + .14B(1943) + .42B(1967) < EAB < .07B(1976) + .14B(1959) + .42B(1943) + .37B(1967)$$

For salinity and shipping losses:

$$.02B(1976) + .07B(1959) + .04B(1943) + .44B(1967) < EAB < .09B(1976) + .04B(1959) + .44B(1943) + .43B(1967)$$

Estimation of the benefits for each of the four years was carried out using a model called the Distribution Model, which simulates the major components of the surface water system of the Netherlands [15]. Given information over time on how much water enters the country (from rivers, rainfall, and groundwater flows), and how much water is extracted by the various user groups, the model calculates the water flows in the major rivers and canals, the levels of the lakes, and the concentration of salt in these waters. Using this information, it calculates the agricultural shortage and salinity losses, and losses to shipping from low water flows and lock delays.

SCREEN 1: BOUNDING THE SPACE OF PROMISING ALTERNATIVES

For purposes of the analysis, the Netherlands was divided into eight regions (see Fig. 5). The general approach to screening technical and managerial tactics was to prepare a list of potential tactics for each region and to evaluate each one using a small subset of the impact measures. However, before preparing these lists, a pre-screening analysis (Screen 1) was conducted to identify those regions and scenario

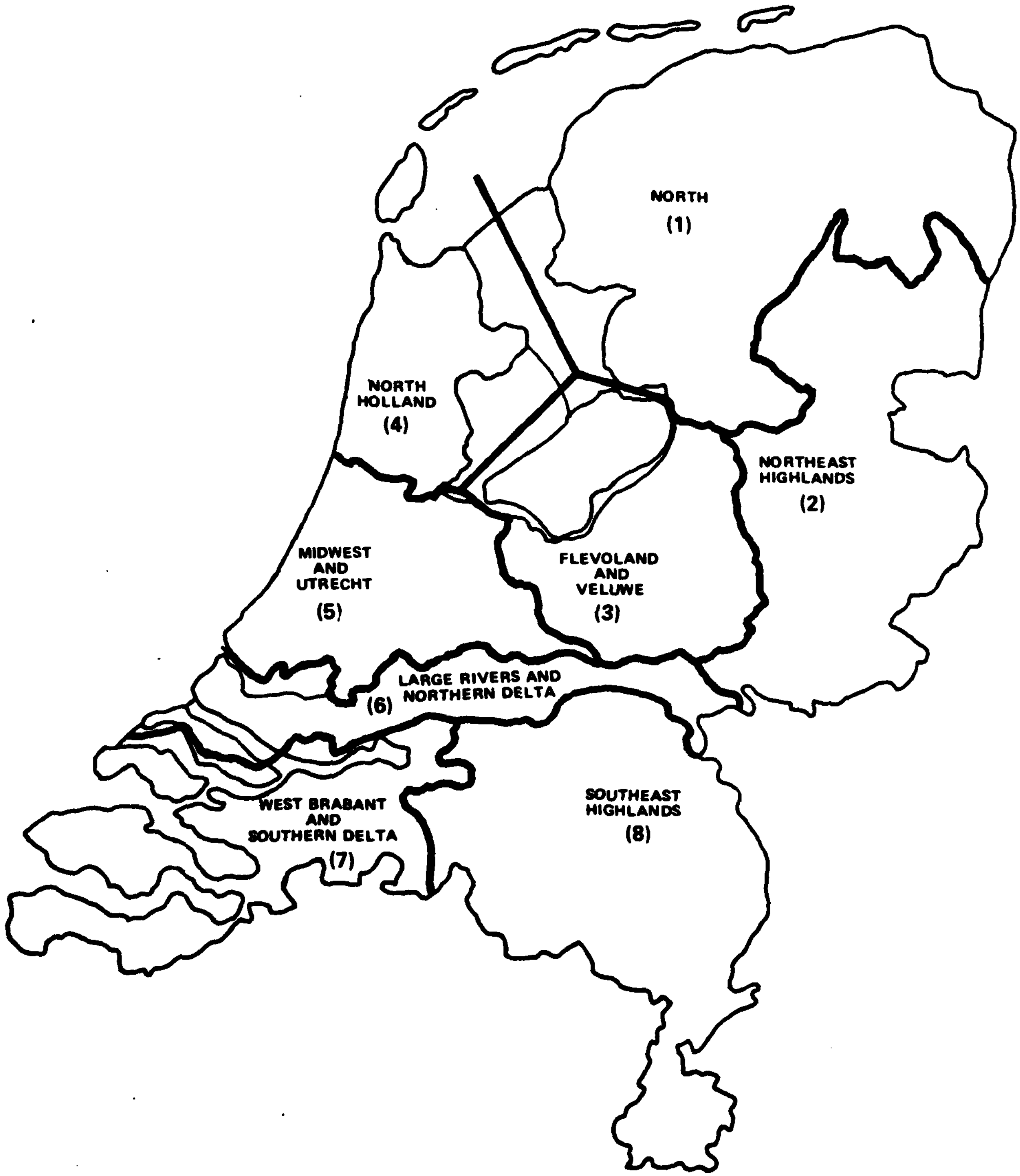

Fig. 5 — PAWN analysis regions

assumptions[5] for which the costs of implementing tactics were unlikely to be offset by the expected annual benefits in terms of reduced crop losses. These regions could then be ignored in the subsequent analysis (except if they had serious problems with respect to other impact measures).

For each region and several demand and supply scenarios, estimates were made of the agriculture shortage losses that would occur (1) with the existing water management infrastructure, and (2) if the infrastructure were expanded so that there were no shortage losses in areas with access to surface water (i.e., the demands for irrigation water were fully met).

The difference between the two estimates of shortages losses (which was called the *preventable losses)* would be the maximum benefits that could be expected from any tactics designed to reduce water shortages in the region. An upper bound on the preventable losses was obtained by making use of the formula for shortage losses presented above. Letting L(y) be the preventable losses in year y, an upper bound on the expected annual preventable losses (UB) is given by:

$$UB = .07L(1976) + .14L(1959) + .42L(1943) + .37L(1967).$$

Table 3 presents the maximum benefits by region for two demand scenarios--a low demand scenario (corresponding to the current use of water for irrigation) and a high demand scenario (representing projected future demand). The results show that unless the demand for irrigation water increases substantially, preventable shortage losses are expected to be small, so few if any tactics are needed. Thus, the next stage of the screening analysis (Screen 2) was limited to the high demand scenario, except for tactics involving Region 8. In addition, since the maximum benefits for Regions 3 and 6 were very low in both scenarios, no technical tactics for reducing agriculture shortage losses in these two regions were analyzed.

[5] A scenario consisted of factors that are uncertain and whose value will be determined by outside processes (political or natural) beyond the control of water management decisionmakers. The scenario variables included the amount of sprinkler equipment that would be installed by farmers, and the amount of salt that would be dumped into the Rhine River outside the Netherlands.

Table 3

UPPER BOUNDS ON EXPECTED ANNUAL PREVENTABLE LOSSES

(In Millions of Guilders)

Region	Low Demand	High Demand
1	0.0	7.5
2	0.6	19.9
3	0.0	0.2
4	0.0	0.7
5	0.8	4.2
6	0.0	0.3
7	0.0	0.5
8	3.7	28.1

SCREEN 2: USING FEW IMPACT MEASURES

The second phase of the screening analysis began with the compilation of a list of technical and managerial tactics that were designed to resolve the national and regional shortage and salinity problems. The major sources of tactics were reports prepared by the Rijkswaterstaat and discussions with Dutch water management experts. In addition, the results of Screen 1 led to the identification of new tactics aimed at reducing agriculture shortage losses in Regions 2 and 8, where the preventable losses were particularly high. A total of 57 tactics were analyzed in Screen 2.

The Distribution Model was used to estimate the expected annual benefits of each of the tactics. The model was run four times for each of the tactics--once for each supply scenario (1976, 1959, 1947 and 1967). Then the formulas given above were used to obtain upper and lower bounds on the expected annual shortage losses, salinity losses, and shipping losses. The losses were summed to obtain the expected annual benefits (EAB), which were then compared to the tactic's annualized fixed cost (AFC). If the AFC exceeds the upper bound on the EAB, the tactic is clearly not promising. If the AFC is less than the lower bound on the EAB, the tactic is clearly worth further consideration. It was decided to pass along to the impact assessment phase all tactics whose AFC was less than the upper bound on the EAB, recognizing that the expected annual benefits might in fact turn out to be less than the annualized fixed cost.

To illustrate how the Screen 2 analysis was performed, the analysis of one of the tactics is summarized below. The tactic analyzed involves building a canal to reduce agriculture salinity losses in Region 5. Some of the country's most valuable crops are grown in this region--the world renowned Dutch bulbs (tulips, hyacinths, etc.), greenhouse vegetables (mainly tomatoes, cucumbers, and lettuce), and greenhouse flowers (mainly roses, carnations, and chrysanthemums). All are quite sensitive to salt. The principal inlet point for the region's surface water is located along the Hollandsche IJssel at Gouda (see Fig. 6).

The proposed solution for this problem was to extract water for the region at a point further upstream, where there was no danger of contamination from North Sea salt water. The water would be transported to Gouda via a new canal to be built through the portion of the country known as the Krimpenerwaard (see Fig. 6).

The benefits from the canal were measured by the reduction in agriculture salinity losses in Region 5. These benefits are partially offset by increases in shipping losses caused by reduced flows on one of the country's major rivers, which would supply water to the canal. Distribution Model runs were made with and without the Krimpenerwaard Canal using the high demand scenario and the 1976, 1959, and 1943 external supply scenarios. (No year wetter than 1943 was run because it was clear that the canal would not be needed in such years.) The differences between the salinity and shipping losses in the two sets of runs (with and without the canal) were used as the benefits to be derived from building the canal. Table 4 presents the results derived from these runs, as well as the upper and lower bounds calculated from them.

The numbers in Table 4 provide several important insights. First, North Sea salt is a serious problem only in an extremely dry year such as 1976. Second, the increased losses to shipping from this tactic are significant. In fact, in 1959 and 1943 they outweigh the reductions in salinity losses that the tactic achieves. Finally, the upper bound on the tactic's expected annual benefits is less than its annualized fixed cost, which means that it is not a promising tactic. It was therefore

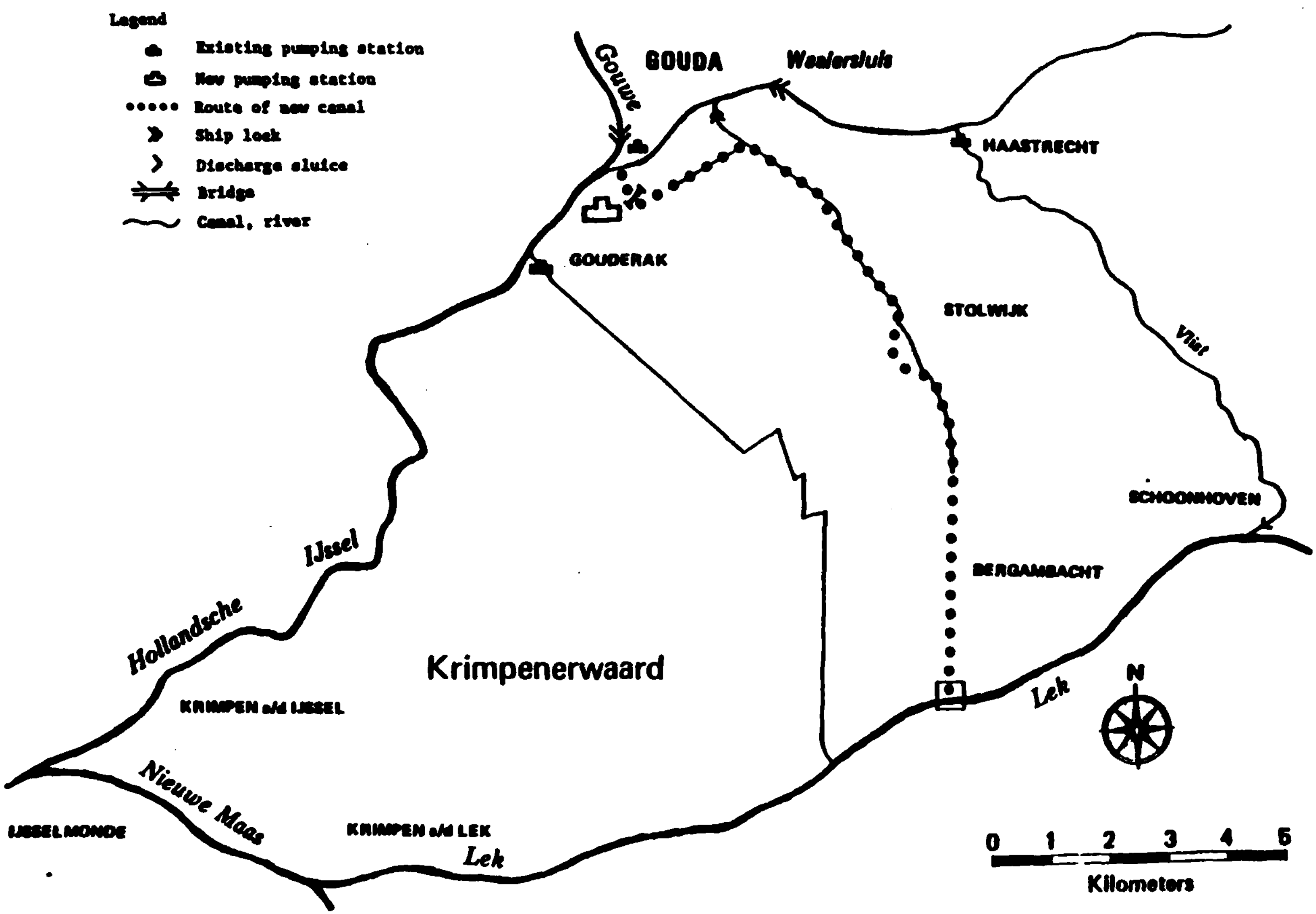

Fig. 6 — Route of Krimpenerwaard canal

screened out--i.e., not examined further in later stages of PAWN.

SCREENING RESULTS AND CONCLUSIONS

Screening in the PAWN project was a simple and inexpensive, yet powerful way to reduce the effort that might have been required to evaluate many potentially valuable alternatives against scores of impact measures. The expressed purpose of screening was to select from the large number of potential tactics a reasonably small number that merited a more detailed evaluation. This objective was achieved. But screening accomplished more than just producing intermediate results to be used as inputs to the next phase of the project. It produced insights that have helped to guide subsequent water resources planning in the Netherlands.

First, Screen 1 showed that there are relatively few tactics for reducing agriculture shortage losses that are worth considering further, unless the demand for surface water were to increase significantly above current levels. It also showed that it would not be worth the effort to generate or evaluate any alternatives for reducing shortage losses in two of the eight regions of the country.

The insights from Screen 2 were even more valuable and somewhat surprising. Prior to the PAWN study, the Dutch had been considering several large, expensive construction projects. Almost all of these

Table 4

COMPARISON OF BENEFITS AND COSTS OF BUILDING
A KRIMPENERWAARD CANAL

(millions of guilders)

Type of Benefit	External Supply Scenario 1976	1959	1943	1967	Expected Annual Benefits Upper Bound	Lower Bound	Annualized Fixed Cost
Salinity	41.5	0.2	0.0	0.0			
Shipping	(6.9)	(2.4)	(0.3)	0.0			
Net	34.7	(2.2)	(0.3)	0.0	2.9	0.5	5.7

projects were screened out because the costs of construction were greater than the most optimistic assessment of the potential benefits. Savings to the Dutch government from not proceeding with those projects are estimated in the hundreds of millions of dollars.

Except for a few very inexpensive national tactics, most of the promising tactics primarily affect a single region. This suggested that the national water management infrastructure is functioning rather well, and that future water management analysis and policymaking should be focused more on regional water management problems.

Nine inexpensive regional construction projects were shown to be highly cost-beneficial. These tactics, together with five national tactics, were passed on to the impact assessment phase of the project. Six of these fourteen tactics were found to be promising, independent of the demand scenario used. They include two aimed at reducing agriculture salinity losses, one that will help reduce agriculture shortage losses, two that will reduce low water shipping losses, and one that is designed to reduce the chance of flooding. The total annualized fixed cost for all six tactics is less than $3 million. For the high demand scenario, eight more tactics were found to be very attractive. Eleven others, although promising, are dominated by one of those eight (i.e., they attack the same problem, but have higher costs and/or lower benefits).

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